Logistics Reduction: Trash Compaction and Processing System (LR-TCPS)

Active Technology Project (2014 - 2024)

Project Introduction

The Advanced Exploration Systems, Logistics Reduction project called the Trash Compaction and Processing System (TCPS) is a waste management technology. Currently, there are no trash management practices that are being implemented in the space environment other than manual compaction of waste into a plastic bag. The current practice does not recover critical resources such as water, does not prevent the growth of potentially harmful microbiological pathogens, and provides only limited volume reduction.

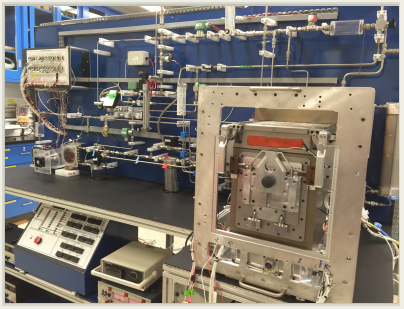
The objective of the TCPS task is to develop a reliable trash processing system to support long endurance human space missions (target TRL 8/9). The TCPS itself is a project that plans an International Space Station (ISS) technology demonstration.

The TCPS objectives are to: *reduce volume of trash*, *safen* processed trash to reduce risk of biological activity, *stabilize* processed trash for efficient storage and disposal, and to *recover water and manage gaseous effluents*. Processed TCPS trash appear as tiles and can be used for radiation shielding augmentation. For a one-year, four-person crew mission, it is estimated that TCPS could recover ~8 cubic meters of habitable volume, produce over 900 kg of radiation shielding tiles, and recover 230kg of water from ~1,300 kg of trash. Additionally, the tiles could be jettisoned during a transit mission to reduce propellant needs.

FY2012-FY2018

This period saw the development of the Heat Melt Compactor (HMC). The HMC is a full-scale TCPS precursor that was developed to refine previous versions' trash processing capabilities, finalize operational parameters, and identify hardware issues. During the period between FY2012 and FY2016 various trash compactor prototypes were developed. This included an SBIR Phase 2 Plastic Melt Compactor System developed by Orbital Sciences Corporation (aka Sierra Nevada Corp), and the Generation 1 HMC developed at Ames. In FY2016, a Generation 2 (Gen2) HMC with an ISS "flight-like" design was designed and built at Ames. Limited Gen2 HMC ground testing began in 2017 but was not completed due to inability to reach desired compaction pressure and vacuum. In FY2018, the hardware was repaired to partially restore its desired capability. Several SBIR awards related to the HMC have occurred in the following areas: microgravity-compatible condensing heat exchanger designs, trash bag liners to allow hygienic tiles after HMC processing, and general HMC system design.

FY2019 – FY2021



The Gen 2 HMC (right) with the Water Recovery System (WRS) in the background.

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In FY2019, two contractors were selected for Phase A contracts under the NASA Next Space Technologies for Exploration Partnerships (NextSTEP) Appendix F: Logistics Reduction in Space by Trash Compaction and Processing System (TCPS), Broad Agency Announcement (BAA). The two contractors were the Sierra Nevada Corporation (SNC) and UTC Aerospace Systems (UTAS), also known as Collins Aerospace. The BAA is given here: https://www.nasa.gov/feature/nasa-selects-two-companies-to-help-take-out-the-deep-space-trash/

Phase A was implemented in FY19-20 and completed in FY20. Phase A developed and validated TCPS flight concepts to inform SNC and Collins in flight hardware development. Risk reduction activities at NASA's Ames Research Center (ARC) HMC facility in support of the Phase A contractors' work included: gas and water effluent analysis, system operations, product quality, and design analysis including 15 trash processing runs of various trash models. Collins completed their compactor development work in June 2020 and SNC completed their work of a compactor, water recovery, and effluent gas management in October 2020.

In FY2020 and FY2021, the ARC team continued risk reduction activities that included tests of the HMC Gen2 under different operational scenarios. The information gained was used to inform Phase A TCPS contractors as they developed their PDR-lite designs and prototypes. A HMC/TCPS Generation 3 (Gen3) by SNC was delivered to NASA ARC as part of a SBIR Phase II by Materials Modification Incorporated (MMI). MMI developed high-temperature, low outgassing, and semi-permeable bags for use with the HMC.

Phase A work was completed in FY2021, but the contract was extended into FY2022.

FY2022 – present

The knowledge accumulated in Phase A will guide the FY2022 NextSTEP BAA Phase B TCPS procurement. Phase B includes an open solicitation to down

Organizational Responsibility

Responsible Mission Directorate:

Exploration Systems Development Mission Directorate (ESDMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

Exploration Capabilities

Project Management

Program Director:

Christopher L Moore

Project Managers:

Melissa K Mckinley
Jeffrey M Lee
Steven A Sepka

Principal Investigator:

Jeffrey M Lee

Co-Investigator:

Michael K Ewert

select to one contractor between SNC and Collins. Phase B is expected to be awarded as a three-year project (FY22-25), ending in an ISS flight demonstration planned for ~2025, with the possibility for continued use to support ISS operations.

The HMC/TCPS Gen3 that was delivered to ARC in FY21 will be used to supply test gases for the Source Contaminant Control System (SCCS). A particulate matter measurement system will be used to determine particulates given off during use of the TCPS system.

The SCCS is designed to remove toxic gases such as CO, CH4, and volatile organic compounds. This system consists of an activated charcoal adsorbent bed and a catalytic oxidizer. Precision Combustion Inc. (SBIR Phase II) sized the SCCS catalytic oxidizer for use with the HMC/TCPS. Testing may also include using known ISS cabin toxins as part of the TCPS inlet gases to characterize SCCS performance. Gen3 processing will also be tried at lower temperatures to see if a tailored Trash-to-Gas feedstock can be easily created.

The ARC team is working with Glenn Research Center's aerosol team to design a particulate matter system to measure and monitor particulates released during TCPS operations: trash loading, tile removal, and handling of the product tiles. The particulate matter system consists of a SBIR Phase II analyzer which is similar to current ISS flight hardware. Additionally, semi-permeable trash containment bags from MMI and ISS-approved wet trash bags will be tested for their ability to prevent the release of particulates during tile TCPS operations while reducing gas and water contaminants and still allowing water recovery.

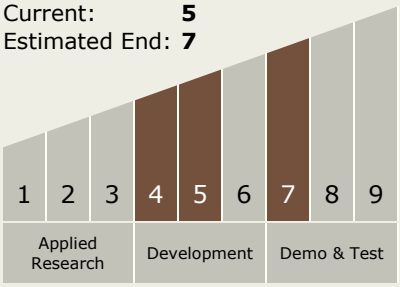
Anticipated Benefits

The TCPS technology would benefit any long-duration operation with limited habitable volume. The goal is to reduce trash volume and microbiologically inactivate it. This will provide less odor generation and improve habitat hygiene. As an alternative to radiation shielding, increased habitable volume, and recovered water, TCPS processed trash could be processed further using trash-to-gas technology to produce methane, or the tiles could be a compact form for trash disposal/ejection from the vehicle.

TCPS will develop a highly reliable technology primarily for reducing trash volume. TCPS will also recover water from waste materials and produce microbiologically-stable, low volume tiles for radiation protection, storage or

Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **7**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.1 Environmental Control & Life Support Systems (ECLSS) and Habitation Systems
    - TX06.1.3 Waste Management

Target Destinations

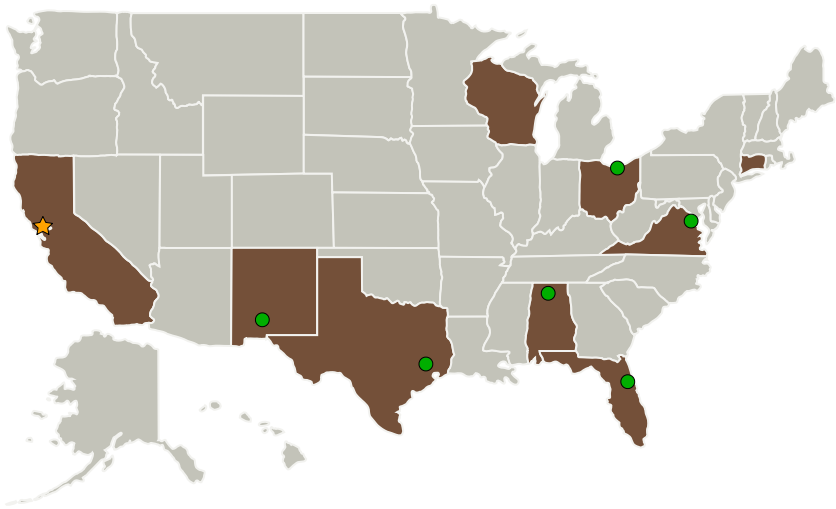
Earth, The Moon, Mars

Supported Mission Type

Projected Mission (Pull)

disposal. For a one-year mission of four crew, it is estimated that HMC could recover ~8 cubic meters of habitable volume, produce over 900 kg of radiation shielding tiles, and recover 230-720 kg of water.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California
●Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio
●Johnson Space Center(JSC)	Supporting Organization	NASA Center	Houston, Texas
●Kennedy Space Center(KSC)	Supporting Organization	NASA Center	Kennedy Space Center, Florida
●Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama
●NASA Headquarters(HQ)	Supporting Organization	NASA Center	Washington, District of Columbia
●White Sands Test Facility(WSTF)	Supporting Organization	NASA Facility	Las Cruces, New Mexico

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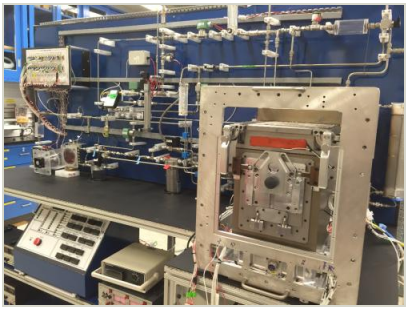
Co-Funding Partners	Type	Location
Materials Modification, Inc.	Industry Small Disadvantaged Business (SDB)	Fairfax, Virginia
Sierra Nevada Corporation(SNC)	Industry Women-Owned Small Business (WOSB)	Sparks, Nevada
United Technologies Aerospace Systems	Industry	

Primary U.S. Work Locations	
Alabama	California
Connecticut	District of Columbia
Florida	New Mexico
Ohio	Texas
Virginia	Wisconsin

Images



Generation 2 Heat Melt Compactor
The Gen 2 HMC (right) with the Water Recovery System (WRS) in the background.
(https://techport.nasa.gov/image/143368)

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Links

NASA NextSTEP-2 Appendix F, 'Trash Compaction and Processing System (TCPS)'
(https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=02c782d135f3d5414905697e89ef4473)